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R. G. VYVERBERG

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ELECTROSTATIC CHARGING APPARATUS

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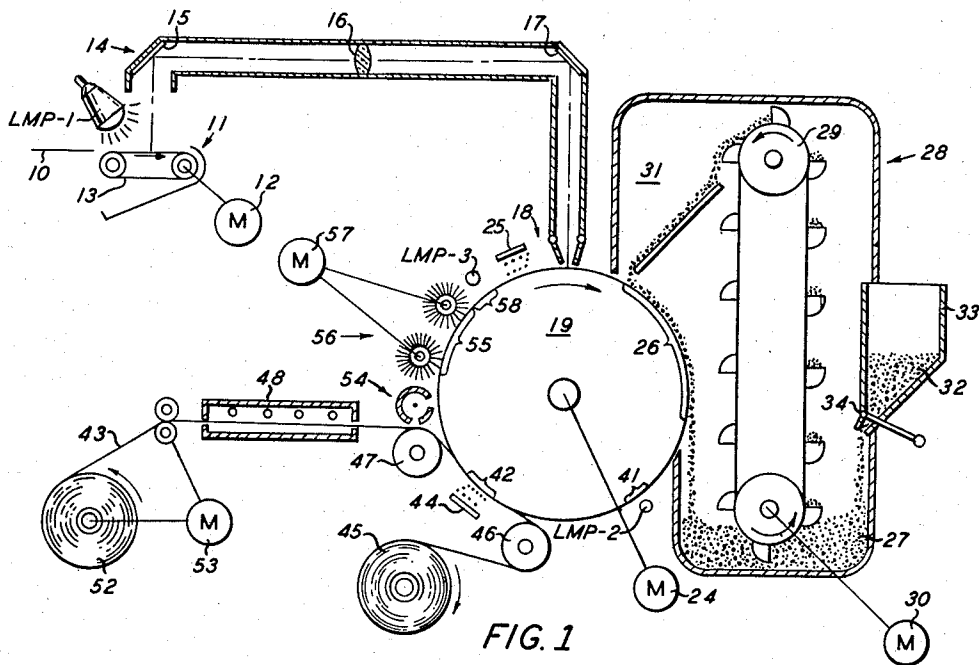


FIG. 1

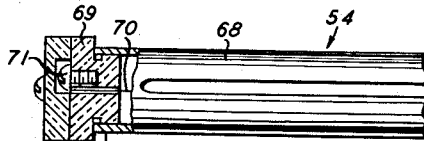


FIG. 2

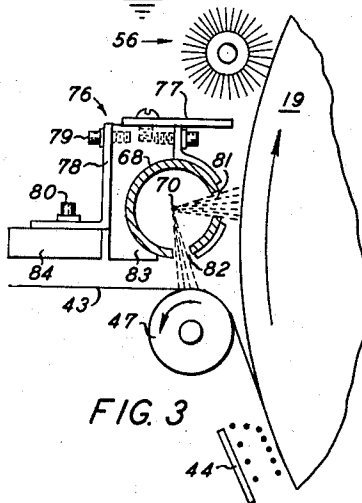


FIG. 3

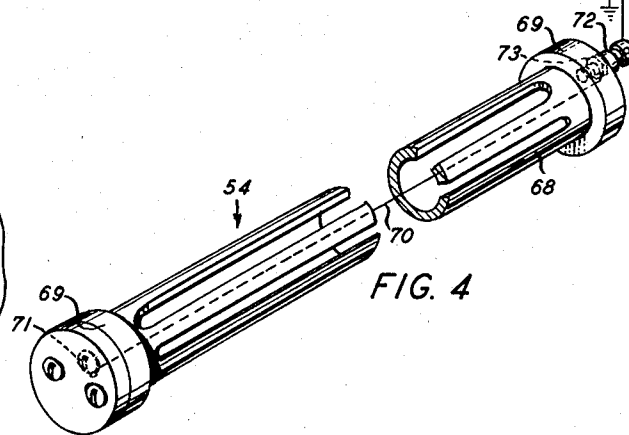


FIG. 4

INVENTOR.
ROBERT G. VYVERBERG

BY *Robert G. Vyverberg*
ATTORNEY

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ELECTROSTATIC CHARGING APPARATUS

Robert G. Vyverberg, Pittsford, N.Y., assignor to Haloid Xerox Inc., Rochester, N.Y., a corporation of New York

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This invention relates to xerography and particularly to an improved corona generating device from which corona ions are emitted in a plurality of controlled directions. More specifically the invention relates to a corona generating device from which corona ions are directed simultaneously to at least two independent surfaces to be charged which are located substantially adjacent thereto.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the radiation intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material such as an electroscopic powder that is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed xerographic powder image is usually transferred to a support surface to which it may be fixed by any suitable means.

In automatic equipment employing the principles of xerography it is common to employ a xerographic plate in the form of a cylindrical drum which is continuously rotated through a cycle of sequential operations including charging, exposure, developing and transfer during which copy is reproduced on a support surface and after which the plate is cleaned before repeating the cycle.

It is usual to charge the plate with corona of positive polarity by means of a corona generating device, which when supplied with potential above the corona threshold produces an emission of corona ions. Corona generating devices are commercially marketed by Haloid Xerox Inc. of Rochester, New York, and may be employed for producing either positive or negative corona. Typical embodiments of corona generating devices are disclosed in Walkup Patent 2,777,957 and in Vyverberg Patent 2,836,725. Apparatus of the former is referred to in the art as a "scorotron" and includes a plurality of high voltage corona discharge electrodes which are generally referred to in the art as "coronode" wires that are combined with a wire screen for regulating corona emission, and apparatus of the latter is referred to in the art as a "corotron" which utilizes only a single coronode wire.

Development of an electrostatic latent image forms a powder image on the plate which is electrostatically transferred to a support surface by means of a corona generating device such as mentioned above. In the automatic type of equipment employing a rotating drum, a support surface to which a powder image is to be transferred is moved through the equipment at the same rate

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as the periphery of the drum and contacts the drum at the transfer position interposed between the drum surface and the corona generating device. Transfer is effected by the corona generating device which imparts an electrostatic charge to attract the powder image from the drum to the support surface. The polarity of charge required to effect image transfer is dependent upon the form of the original copy relative to the reproduction and the electroscopic characteristics of the developing material employed to effect development. As for example, where a positive reproduction is to be made of a positive original, it is usual to employ a developing material which is triboelectrically charged to negative polarity, and after formation of a powder image, positive polarity corona is used to effect transfer to the support surface. In contrast, to produce a positive reproduction from a negative original, it is usual to employ a positively charged developing material which is repelled by the non-image areas on the plate to the discharged image areas thereon and negative polarity corona is employed to effect transfer.

In the positive-to-positive type of reproduction described above, considerable difficulty has heretofore been encountered after transfer both in cleaning the drum surface and in a phenomenon produced on the support surface commonly referred to in the art as "static discharge marks" wherein, after separation of the support surface from the drum, the powder image appears to "explode" causing deterioration of image quality.

With regard to the problem of drum cleaning, it is known that a residuum of developer is retained on the drum surface either by electrical or other forces and does not transfer completely to the support surface. In cases involving negative-to-positive image reproduction, brush cleaning is usually adequate to remove substantially all of the residual powder from the drum. This is achieved because the negative corona employed during image transfer leaves the residuum of powder negatively charged. Since the brush bristles of the type presently employed for cleaning develop a net positive charge, brushing the drum surface not only removes the developer by brushing action, but the developer is also electrostatically attracted into the brush wherefrom it is usually carried off by a withdrawing stream of air.

However, in positive-to-positive reproduction the charge relation appears to be such that rubbing or brushing alone by means such as a rotating brush does not completely effect removal of the residual powder. In continuous operation, a film of developer tends to build up on the drum surface and adversely affects the quality of subsequent reproductions. Although the phenomenon is not fully understood, it is believed that an air breakdown occurs between the drum and support surface after their separation due a high field strength and growth of the air gap to a critical length. From positive transfer, it is believed that this break-down deposits additional positive charge on the drum, changing polarity of the developer from negative to positive. The brush, which inherently takes on a positive triboelectric charge, tends to repel rather than remove at least a portion of the positively charged residual developer, thus inhibiting complete powder removal.

A method to facilitate removal of residual developer, as associated with positive-to-positive xerographic reproduction, is disclosed in Walkup Patent 2,752,271 whereby electrostatic charge is applied to the drum surface between the transfer and cleaning operations substantially to neutralize the residual developer charge. As part of the present invention improved apparatus is provided for applying such an electrostatic charge.

The phenomenon of static discharge marks also is not

fully understood but from extensive testing it has been observed that the moisture content of the support surface has a direct bearing on the production of discharge marks. With paper support surfaces having a moisture content in excess of six percent, image defects are not apparent; but with drier paper, the defects are more prominent. It is theorized, therefore, that during transfer the degree of build up of static charges in the paper is dependent upon its moisture content, i.e., the more moist the paper the more electrically conductive it becomes. It appears that on contact after transfer with a grounded guide roll, a relatively conductive paper discharges its static whereas with a drier relatively non-conductive or insulator paper, on separation of the paper from the grounded guide roll the static charge tends to "spark" between the paper and the roll causing the loosely adhering powder image particles to separate. After extensive study, it was found that image distortion caused by static discharge can be eliminated by applying opposite polarity corona to the paper web support surface after transfer and prior to its separation from the grounded guide roll. It is therefore a part of this invention to provide apparatus for applying such an electrostatic charge to the web.

The principal object of the invention is to apply electrostatic charge to two or more surfaces simultaneously by means of a single corona generating apparatus.

A further object of the invention is to eliminate static discharge marks and image distortion occurring on a xerographic support surface after image transfer thereto.

A further object of the invention is to facilitate cleaning of a xerographic plate by means of electrostatic discharge applied to a residual image with an improved corona generating apparatus.

These and other objects of the invention are attained by means of an improved type of corona generating device whereby electrostatic charge may be applied to the xerographic drum surface and support surface simultaneously from a single corona generating source. Specifically, this is achieved by arranging a corotron type of corona generating device in proximity to the drum and supporting surface and directing a controlled application of electrostatic charge to the respective surfaces from a plurality of longitudinal openings in the corotron shield.

A preferred form of the invention is shown in the accompanying drawings in which:

Fig. 1 schematically illustrates an automatic xerographic unit employing the apparatus of the invention;

Fig. 2 is a plan view of the corona generating device of the invention partially broken away to facilitate understanding of its construction;

Fig. 3 is an enlarged cross section of the corona generating apparatus shown supported in relation to the xerographic drum and support surface similarly as in Fig. 1; and

Fig. 4 is an isometric illustration of the corona generating apparatus of the invention.

For a general understanding of the xerographic processing system in which the invention is incorporated, reference is had to Fig. 1 in which the various system components are schematically illustrated. As in all xerographic systems based on the concept disclosed in the above-cited Carlson patent, a radiation light image of copy to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is usually developed with an oppositely charged developing material to form a xerographic powder image, corresponding to the latent image, on the plate surface. The powder image is then electrostatically transferred to a support surface to which it may be fused by any suitable form of fusing device, whereby the powder image is caused permanently to adhere to the support surface.

The xerographic apparatus described herein typically may be of the type disclosed in copending application

Serial No. 837,173, filed August 31, 1959, in the names of A. J. Cerasani et al. In the apparatus referred to, opaque copy to be reproduced, which is usually positive in form, is placed on a support tray 10 from which it is fed onto a transport mechanism generally designated as 11. Suitable drive means are provided for the transport mechanism from motor 12 to endless belts 13 whereby the copy is moved past the optical axis of projection lens system 14 that is illuminated by a projection lamp LMP-1. The image of the copy is reflected by mirror 15 through an adjustable objective lens 16 and then reflected by mirror 17 downwardly through a variable slit aperture assembly 18 and onto the surface of a xerographic plate in the form of drum 19.

Xerographic drum 19 includes a cylindrical member mounted in suitable bearings in the frame of the machine and is driven in a clockwise direction by a motor 24 at a constant rate that is proportional to the transport rate of the copy, whereby the peripheral rate of the drum surface is identical to the rate of movement of the reflected light image. The drum surface comprises a layer of photoconductive material on a conductive backing that is sensitized prior to exposure by means of a screened corona generating device 25, which may be an adaptation of the type disclosed in Walkup patent above cited, that is energized from a suitable high potential source.

The exposure of the drum to the light image discharges the photoconductive layer in the areas struck by light, whereby there remains on the drum a latent electrostatic image in image configuration corresponding to the light image projected from the copy. As the drum surface continues its movement, the electrostatic latent image passes through a developing station 26 in which a two-component developing material 27, which may be of the type disclosed in Walkup Patent 2,638,416, is cascaded over the drum surface by means of developing apparatus 28 which may be of the type disclosed in copending application Serial No. 393,058, filed November 19, 1953, in the names of C. R. Mayo et al.

In the developing apparatus, developing material is carried up by conveyor 29 driven by suitable drive means from motor 30 and is released onto chute 31 wherefrom it cascades down over the drum surface. Toner component 32 of the developer which is consumed in developing is stored in dispenser 33 and is released in amounts controlled by gate 34.

After developing, the xerographic powder image passes a discharge station 41 at which the drum surface is illuminated by a lamp LMP-2, whereby residual charges on the non-image areas of the drum surface are completely discharged. Thereafter, the powder image passes through an image transfer station 42 at which the powder image is electrostatically transferred to a support surface web 43 by means of a second corona generating device 44 similar to corona charging device 25, mentioned above.

The support surface to which the powder image is transferred may be of any convenient type such as paper and is obtained from a supply roll 45 and is fed over guide rolls 46 and 47, which are grounded through the apparatus, and over suitable tensioning rolls being directed into surface contact with the drum in the immediate vicinity of transfer corona generating device 44. After transfer, the support surface is separated from the drum surface and guided through a suitable fusing apparatus 48 which may be an adaptation of the type disclosed in Crumrine Patent 2,852,651, whereby the powder image is permanently affixed to the support surface. Thereafter, the support surface is fed over a further system of guide and tensioning rolls and onto a take-up roll 52 that is driven by motor 53.

After separation of the support surface from the drum, a corona generating device 54, constructed in accordance with the invention as described below, directs negative electrostatic charge to the residual powder image on the

drum surface and to the support surface before leaving guide roll 47.

After transfer and negative charging, the xerographic drum surface passes through a cleaning station 55 at which its surface is brushed by a cleaning brush assembly 56, rotated by a motor 57, whereby residual developing material remaining on the drum is removed. Thereafter, the drum surface passes through a second discharge station 58 at which it is illuminated by a fluorescent lamp LMP-3, whereby the drum surface in this region is completely flooded with light to remove any electrostatic charge that may remain thereon. Suitable light traps are provided in the system to prevent any light rays from reaching the drum surface, other than the projected image, during the period of drum travel immediately prior to sensitization by corona generating device 25 until after the drum surface is completely passed through the developing station 26.

In a typical embodiment of the invention disclosed herein, the charging apparatus for simultaneously applying electrostatic charge to the drum surface and support surface is preferably an adaptation of the corona generating device disclosed in the above-mentioned Vyverberg patent.

Referring to Fig. 2, a corotron constructed in accordance with the invention is illustrated and shown connected to a potential source 67. In a typical embodiment, the corotron is shown with a conductive shield 68 that is substantially tubular in shape and connected to ground. The shield is connected at each end to insulator blocks 69. In the view of Fig. 2 the discharge electrode 70 is secured at the left to the insulator block by screw 71 and at the right is wound around conductive plug 72 and secured thereat by nut 73.

Referring also to Fig. 3, the corotron of the invention is shown in application for simultaneously directing negative corona to residual developer on the drum occurring between the transfer and cleaning operations and to the support surface web 43 after separating from the drum and before separating from grounded guide roll 47. Potential above the corona threshold, which is supplied to the discharge electrode through conductive plug 72, may be in the approximate range of 4800 to 6200 volts and may arbitrarily be selected at 5400 volts. It is to be noted that the application described for charging two surfaces is typical and any number of surfaces may be similarly charged with corona of either positive or negative polarity.

The corotron is supported in the machine by means of a pair of brackets 76 that are secured in the machine by suitable means and are adapted to grip the corotron near its ends. Each bracket includes a support angle 78 having two elongated slots through which screws 79 and 80 are secured to bars 83 and 84, respectively. By securing the vertical position of bar 83 and the horizontal position of angle 78 the spacing between the corotron and the surfaces to be charged can be easily adjusted. At the top of the brackets is a dust shield 77 which prevents loose developer removed by the brushes from falling into the corotron and adversely affecting its operation.

In the arrangement shown, two openings 81 and 82 through which corona is emitted are provided in the shield angularly displaced from each other and extending substantially coterminous with the drum width and web width respectively. Whereas in Fig. 3 corona charge emanating from wire 70 is shown being emitted only through the openings, it is to be understood that the corona charge radiates uniformly from the coronode wire to the shield and is shown in this manner for sake of clarity of illustration.

Although tubular shield construction is illustrated and has been found to produce satisfactory results, it is not a geometric limitation and various other configurations of shield, for example, as disclosed in above-cited Vyverberg patent, may be employed. In a typical embodiment

found to produce excellent results the shield 68 is constructed of $\frac{3}{8}$ " diameter brass tubing extending coaxially with a discharge electrode 70 which may be of stainless steel wire approximately .003" in diameter. With variation in input voltage a variety of shield and wire sizes in combination could be effectively employed to produce corona current of a desired magnitude. Therefore, neither the given dimensions nor the shield and wire composition is considered to be structural limitations. However, with increasingly larger shield and/or wire dimensions the input potential necessary to produce the desired corona current increases to a point where the power supply therefore becomes economically infeasible, whereas too small a wire is fragile and too small a shield may result in sparking between the wire and the shield. Acceptable results have been obtained when employing tubular shield dimensions in the approximate range of $\frac{3}{8}$ " inside diameter to $1\frac{1}{8}$ " inside diameter and wire diameters in the range from .002" through .010". However, it must be noted that these dimensions are considered to be practical although not critical limitations.

It has been found that a bare drum current on the order of 4 microamperes, produced with a potential of 5400 volts on the discharge electrode, adequately facilitates brush cleaning under normal operating conditions. The magnitude of current required to facilitate cleaning has been found to be a function of variables such as atmospheric conditions, consumption rate of developer toner and other influencing factors and under various operating conditions the required drum current has been found to range from 1 to 15 microamperes. In general, these values are attained utilizing an opening of approximately $\frac{1}{4}$ " wide spaced approximately $\frac{3}{16}$ " from the drum surface. With corotron operation set to produce 4 microamperes on the drum as above, it was found that static discharge marks on the web could be eliminated by directing negative corona to the web utilizing an opening width of approximately $\frac{1}{8}$ " spaced approximately $\frac{1}{2}$ " from the web.

In operation, copy to be reproduced is exposed through aperture 18 to the surface of drum 19 which had been previously charged by corona generating device 25. As the drum rotates, the electrostatic latent image formed on exposure is developed by developing apparatus 28 as it passes through developing station 26. Thereafter transfer of the developed powder image is electrostatically effected from the drum to moving support surface web 43 at transfer station 42 by corona generating device 44. After transfer the web separates from the drum whereby the web subsequently passes through fuser 48 to permanently affix the powder image to the web and the drum is subsequently brushed clean by cleaning assembly 56. To facilitate brush cleaning and to prevent static discharge marks on the web after transfer, the corotron of the invention 54 directs negative corona simultaneously to the drum before cleaning and to the web before separating from roll 47.

By apparatus thus described, corona ions may be directed in a plurality of controlled directions by a single corona generating apparatus to simultaneously apply charge to a plurality of independent surfaces which are disposed substantially adjacent thereto.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A corona generating device for directing corona discharge in a plurality of controlled directions, said corona generating device including in combination a single corona discharge electrode, means for connecting the electrode to a source of high potential, a conductive shield substantially surrounding the discharge electrode, and insulating means for supporting the electrode in

spaced relation to the conductive shield, said shield having a plurality of longitudinal openings therein each oriented to permit corona discharge from the corona sheath to be directed in different directions.

2. A corona generating device for directing corona discharge simultaneously onto at least two independent surfaces disposed in charging relation thereto, said corona generating device including in combination a single corona discharge electrode, means for connecting the electrode to a source of high potential, a conductive shield substantially surrounding the discharge electrode, and insulating means for supporting the electrode in spaced relation to the conductive shield, said shield having longitudinal openings therein of like number as the number of surfaces to be charged, said openings being angularly displaced from each other whereby corona discharge from the corona sheath are simultaneously directed to each surface to be charged.

3. A corona generating device for applying corona discharge simultaneously onto at least two independent surfaces disposed in charging relation thereto, said corona generating device including in combination a single corona discharge electrode, means for connecting the electrode to a source of high potential, a conductive shield of tubular cross section mounted coaxially with the discharge electrode and substantially surrounding said electrode, and insulating means for supporting the electrode in spaced relation to the conductive shield, said shield having a plurality of longitudinal openings therein of like number as the number of surfaces to be charged, said openings being angularly displaced from each other whereby corona discharge from the corona sheath are simultaneously directed to each surface to be charged.

4. In a corona generating device for applying corona discharge onto surfaces to be charged wherein said corona generating device includes a single corona discharge electrode, a conductive shield substantially surrounding the discharge electrode, insulating means for supporting the electrode in spaced relation to the conductive shield, and means for connecting the electrode to a source of high potential; the improvement comprising means for simultaneously charging at least two independent surfaces disposed in charging relation thereto, said means including a conductive shield having a plurality of longitudinal openings therein of like number as the number of surfaces to be charged, said openings being angularly displaced from each other whereby corona discharge from the corona sheath are simultaneously directed to each surface to be charged.

5. In a xerographic apparatus wherein at least two independent surfaces which are disposed substantially adjacent to each other are simultaneously to receive an application of corona charge of like polarity, a single corona generating device for applying said charges, said corona generating device including in combination a single corona discharge electrode, means for connecting the electrode to a source of high potential, said electrode being mounted parallel and substantially adjacent to the surfaces to receive the charge, a conductive shield substantially surrounding the discharge electrode, and insulating means for supporting the electrode in spaced relation to the conductive shield, said shield having longitudinal openings therein of like number as the number of

surfaces to receive the charge, said openings being angularly displaced from each other whereby corona discharge from the corona sheath are simultaneously directed to each charge-receiving surface.

6. In a xerographic apparatus wherein after separation of a support surface from a xerographic plate following electrostatic transfer of a powder image to the former from the latter there exist electrostatic forces to be substantially neutralized on the surface of each, a corona generating device for substantially neutralizing the electrostatic forces, said corona generating device including in combination a single corona discharge electrode, means for connecting the electrode to a source of high potential, said electrode being mounted parallel and substantially interposed between the surfaces of the xerographic plate and support surface after separation, a conductive shield substantially surrounding the discharge electrode, and insulating means for supporting the electrode in spaced relation to the conductive shield, said shield having a first longitudinal opening therein oriented to permit corona discharge from the corona sheath to be directed to the xerographic plate, and a second longitudinal opening therein angularly displaced from said first opening and oriented to permit corona discharge from the corona sheath to be directed to the support surface.

7. In a xerographic reproducing apparatus in which a xerographic plate in the form of a drum is mounted for rotation about an axis and is rotated past treating means which includes in related sequence of operation, means to electrostatically charge the drum surface, means to expose copy to be reproduced to the drum surface to form an electrostatic latent image of the copy thereon, means to develop the electrostatic latent image to form a powder image on the drum surface, means to move a support surface into surface contact with the powder image on the drum surface, means to electrostatically transfer the powder image from the drum to the support surface, and means to separate the support surface from the drum whereafter there remains on the drum surface a residual powder image to be removed and on the support surface a charge to be substantially neutralized; the improvement which comprises mounting a corona generating device adjacent the point of separation of the support surface from the drum surface after transfer, said corona generating device including a single corona discharge electrode, means for connecting the electrode to a source of high potential, a conductive shield substantially surrounding the discharge electrode, and insulating means for supporting the electrode in spaced relation to the conductive shield, said shield having a first longitudinal opening therein oriented to permit corona discharge from the corona sheath to be directed to the residual image on the xerographic plate and a second longitudinal opening therein angularly displaced from said first opening and oriented to permit corona discharge from the corona sheath to be directed to the support surface.

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